SUBSTITUTE SPECIFICATION

Title of the Invention:

Self-propelled cleaning device and Charger Using the Same

Background of the Invention:

The present invention relates to an electric cleaning device and a charger to be used therewith; and, more particularly, the invention relates to a self-propelled cleaning device which moves automatically and a charger to be used therewith.

An example of a conventional free-running electric cleaning device is described in Patent Document 1 (Japanese Patent Application Laid-Open Announcement 2002-532177). The electric cleaning device described in this patent application has a body provided with support wheels, a drive means for driving the wheels of the electric cleaning device so as to move the device over a surface to be cleaned in the forward direction, a dust separator, and a fan for pulling air into the dust separator. And, to enable cleaning in contact with a wall, the head of the cleaning device is mounted so as to cross the forward direction and is projected at least on one side of the body. When an obstacle is encountered, the projected head can be pulled into the body.

Another example of a conventional free-running cleaning device is described in Patent Document 2 (Japanese Patent Application 8-83125). The robot cleaning device described in this patent application, in order to automatically charge the battery when the power has been consumed, has a charging level detection means for detecting when the level of charge of the

battery is lower than the a predetermined level, a power supplier for supplying power to the battery, and a power input means for electrically connecting the power supplier and the battery.

Still another example of a conventional free-running cleaning device is described in Patent Document 3 (International Patent Application 02/067745 Pamphlet). The robot cleaning device described in this patent document has a chassis provided with a front bumper and at least two drive wheels. The front bumper can move relative to the chassis, and the robot cleaning device detects relative movement of the chassis and front bumper; and, when the front bumper encounters an obstacle, it transmits a control signal to a guide control system. By doing this, even if an obstacle is encountered, the guide control system can maneuver the robot cleaning device around the obstacle.

The free running electric cleaning device described in Patent Document 1 does not have a means for detecting the amount of projection of a suction body and a means for controlling the suction body on the basis of the positional relationship between a wall and the cleaning device body, so that there is the possibility that, in the corners of a room, dust may be left. Further, the suction body is pressed against the wall by a spring, so that a rubbed mark is often caused on the wall.

Further, in the free running electric cleaning device described in Patent Document 2, when the dust collection case is full of dust, the dust must be dumped by hand. Therefore, in a self-propelled cleaning device whose capacity is limited, the dust must be disposed of frequently, so that it is difficult to completely automate the cleaning device. Furthermore, in the self-propelled cleaning device described in Patent Document 3, only an

obstacle in front of the self-propelled cleaning device can be detected, so that to move backward, the direction of the device must be changed.

The present invention was developed with the foregoing difficulties and problems in view, and an object of the present invention is to provide a self-propelled cleaning device which is capable of cleaning in close proximity to a wall and furniture, including the corners of a room.

Another object of the present invention is to miniaturize the self-propelled cleaning device.

Still another object of the present invention is to automate the charging operation of the self-propelled cleaning device. The present invention is intended to accomplish any of the foregoing objects.

The characteristic of the present invention for accomplishing the above-described objects is to provide a self-propelled cleaning device having a loaded power source that is capable of automatically moving and which has a circular side cover and a suction body which can be stored in this cylindrical cover and which can move transversely relative to the forward direction and in which the suction body can move over the maximum width of the cleaning device.

As a further characteristic, it is preferable to install a base for holding the power source, a suspension for elastically supporting the side cover by the base, and detection means positioned at a plurality of parts in the peripheral direction of the side cover so as to detect the direction of movement of the side cover. Further, it is preferable to install a fan which is arranged in the cleaning device and sucks in air including dust from the suction body, a first dust collection case for collecting dust in the air which is

sucked by the fan, a switchable shutter installed on the outer wall of the dust collection case, and a guide means for connecting the first dust collection means and a second dust collection means arranged outside the cleaning device and to move dust collected in the first dust collection means to the second dust collection means. It is also possible to install charging terminals on the power source for supplying power thereto from an external power source, whereby it is possible to move dust from the first dust collection means to the second dust collection means during charging of the power source.

Another characteristic of the present invention for accomplishing the above-stated objects is in the provision of a self-propelled cleaning device having a suction body for sucking in dust, a dust collection case for collecting dust sucked in by the suction body, a detection means for detecting an article in the vicinity of the cleaning device, and a control means for controlling the direction of movement of the cleaning device on the basis of an output of the detection means. The suction body can be stored in the cleaning device, and a moving means is provided for moving the suction body transversely to the forward direction and an air tight means is provided for holding the dust collection case air tightly even if the suction body is moved by the moving means, and the dust collection case and suction body are in sliding contact with each other.

As a further characteristic, the moving means, when moving the cleaning device by a wall, can move the suction body over the width of the cleaning device, and a control means preferably controls the suction body so as to move at a predetermined distance from the wall or in contact with the

wall on the basis of the output of the detection means. Further, when moving the cleaning device by the wall, the moving means can move the suction body over the width of the cleaning device, and it is desirable to install a means for returning the moved suction body on the cleaning device side.

Still another characteristic of the present invention for accomplishing the above-stated objects is that the power source used in the self-propelled cleaning device has a power supply means for supplying power from a commercial power source to the power source carried in the self-propelled cleaning device, a first contact for electrically connecting the power supply means and the self-propelled cleaning device, and a guide means for guiding the self-propelled cleaning device when connecting a second contact of the self-propelled cleaning device to the first contact. There additionally is an input means for inputting an operation instruction to the self-propelled cleaning device and a means for transferring the operation instruction inputted from the input means to the self-propelled cleaning device.

A further characteristic of the present invention for accomplishing the above-stated objects is that the power source used in the self-propelled cleaning device has a power supply means for supplying power from a commercial power source to the power source carried in the self-propelled cleaning device, a first contact for electrically connecting the power supply means and the self-propelled cleaning device, a guide means for guiding the self-propelled cleaning device when connecting a second contact of the self-propelled cleaning device to the first contact, a suction means and a dust collection means for moving dust collected in the dust collection case carried by the self-propelled cleaning device or a storage unit for storing the self-

propelled cleaning device, and a detection means for detecting entry of the cleaning device into the storage unit and a display means for displaying entry thereof.

As a further characteristic, the cleaning device has a control means for controlling the suction means, and the control means may control the suction means so as to operate when the power supply means is in operation.

Brief Description of the Drawings:

Fig. 1(a) is a top cross sectional view taken along line A-A in Fig. 1(b) and Fig. 1(b) is a side cross sectional view of an embodiment of the self-propelled cleaning device relating to the present invention.

Figs. 2(a) and 2(b) are diagrams illustrating the movable range of the movable body used in the self-propelled cleaning device shown in Fig. 1(a).

Fig. 3 is a top plan view of a top cover used in the self-propelled cleaning device shown in Fig. 1(a).

Fig. 4 is an operational sequence flow diagram illustrating the cleaning method of the self-propelled cleaning device.

Fig. 5 is a partial longitudinal cross sectional view of the self-propelled cleaning device shown in Fig. 1(b).

Fig. 6(a) is a top view and Fig. 6(b) is a side view of the main unit and charger of the self-propelled cleaning device shown in Fig. 1(a).

Fig. 7(a) is a top plan view, Fig. 7(b) is a front view and Fig. 7(c) is a sectional view taken along line A-A in Fig. 7(a) of the guide of the self-propelled cleaning device shown in Fig. 1(a).

Figs. 8(a) and 8(b) are bottom views of the self-propelled cleaning

device shown in Fig. 1(a).

Fig. 9(a) is a top view and Fig. 9(b) is a side view of another embodiment of the self-propelled cleaning device relating to the present invention.

Fig. 10 is a side view of a modification of the self-propelled cleaning device shown in Fig. 9(b).

Description of the Invention:

An embodiment of the self-propelled cleaning device system relating to the present invention will be explained with reference to Figs. 1(a) to 8(b). The self-propelled cleaning device system has a cleaning device 1 that is freely running for picking up dust and a charger 200 for supplying power to a storage battery 22 carried by the cleaning device 1. Fig. 1(a) is a cross sectional view taken along the line A-A shown in Fig. 1(b) and Fig. 1(b) is a longitudinal cross sectional view. The moving direction of the cleaning device 1 is the leftward direction as seen in these drawings.

The structure of the self-propelled cleaning device 1 is formed in an almost cylindrical shape by a top cover 27 and a side cover 23. On respective sides of the lower part in the cleaning device 1, a pair of drive wheels 4a and 4b are mounted. The drive wheels 4a and 4b are individually driven by motors 2a and 2b that are mounted on the base. Speed reducers 5a and 5b for slowing down the output of the motors 2a and 2b are mounted on the motors 2a and 2b.

At the ends of the revolving shafts of the left and right motors 2a and 2b, encoders 3a and 3b are mounted. The encoders 3a and 3b output

signals representing the rotational speeds of the motors 2a and 2b to a controller 6 mounted at the upper back part in the cleaning device 1. The controller 6 individually controls the voltages to be applied to the motors 2a and 2b. The controller 6 feeds back and controls the rotational speeds of the motors 2a and 2b which are detected by the encoders 3a and 3b and thereby controls the rotational speeds of the drive wheels 4a and 4b.

To effect movement in the forward direction, the paired motors 2a and 2b are rotated at the same rotational speed and in the same direction, thus the cleaning device 1 is moved linearly. Further, when the motors 2a and 2b are rotated at the same rotational speed and in opposite directions, the cleaning device 1 is rotated in place.

Hinge pins 8a and 8b support the speed reducers 5a and 5b for rotation around horizontal shafts crossing at right angles to the forward direction. The speed reducers 5a and 5b are connected to the upper part of the cleaning device 1 via suspensions 7a and 7b. When the speed reducers 5a and 5b rotate round the hinge pins 8a and 8b, the drive wheels 4a and 4b move almost vertically. When the cleaning device 1 is placed on the floor, the springs of the suspensions 7a and 7b shrink mostly due to the weight of the cleaning device 1. The drive wheel 4b and the speed reducer 5b are positioned at the position (α) indicated by a solid line in Fig. 1(b). When the cleaning device 1 is lifted up, the springs of the suspensions 7a and 7b are stretched and the speed reducers 5a and 5b and the drive wheels 4a and 4b are moved at a maximum up to the position (β) indicated by a dashed line in the drawing. By doing this, even if the floor surface on which the self-propelled cleaning device 1 moves is uneven, the drive wheels 4a and 4b can

be surely grounded.

On the back side of the cleaning device 1 in the forward direction, there is a suction body 30 that is movable in the transverse direction. The movement of the suction body 30 will be explained with reference to Figs. 2(a) and 2(b). As shown in Fig. 2(a), the suction body 30 is housed within the cleaning device 1 during general operation. In this state, the structure of the self-propelled cleaning device 1 is almost cylindrical. Since the structure of the self-propelled cleaning device 1 is cylindrical, when the cleaning device 1 is not in contact with an obstacle, it can rotate in place free of obstruction. Therefore, the cleaning device 1 can optionally change direction.

However, the structure of the self-propelled cleaning device 1 is not limited to a cylindrical shape, and any rounded shape, such as a semispherical shape or a cut-head conical shape, is acceptable. Even with any of these shapes, the cleaning device 1 can rotate free of obstruction of an obstacle to change the forward direction thereof.

When the suction body 30 is housed entirely within the cleaning device 1, the suction body 30 cannot reach areas in proximity to a wall. In this case, as shown in Fig. 2(b), the tip of the suction body 30 is projected outside beyond the right end (line γ) of the cleaning device 1 within the movable range of the suction body 30. By doing this, the tip of the suction body 30 can reach areas in the neighborhood of a wall.

At the center of the self-propelled cleaning device 1, the storage battery 22 is carried to supply power to each unit. The storage battery 22 is a nickel-hydrogen cell. The voltage of the storage battery 22 is detected by a detection circuit installed in the controller 6. The controller 6 monitors the

detected voltage output and confirms the storage amount of electricity. On the front surface of the cleaning device 1, charging terminals 14 are mounted. When a specified voltage is applied to the charging terminals 14, the storage battery 22 in the cleaning device 1 is charged.

On the upper part of the cleaning device 1, the cover 27 is mounted. The cover 27 is shown in detail in Fig. 3, which is a top view of the cleaning device 1 with the upper side of the drawing representing the forward direction. On the back side relative to the forward direction, an operation panel 46 having a plurality of switches 15, 15, --- is mounted. The switches 15 are used to turn on or off the power source and to output a manual instruction to the self-propelled cleaning device 1. On the operation panel 46, an indicator 17 in the form of a light emission diode is mounted. The indicator 17 indicates that the power source is turned on or off and the residual amount of the storage battery 22. The indicator 47 may also be in the form of a liquid crystal display.

On the top cover 27 in the neighborhood of the operation panel, an infrared remote control receiver 16 is mounted. The receiver 16 is used to receive a signal from an infrared remote control transmitter 100 (not shown in the drawing) which is provided externally. On the basis of a signal received by the receiver 16, the cleaning device 1 can be moved forward or backward or rotated and the dust collection fan can be started or stopped remotely. Further, the automatic cleaning operation can be started or stopped in this way.

On the outer peripheral part of the cleaning device 1, a cylindrical side cover 23 is provided. The upper part of the side cover 23 is curved inward,

and, at its end, the joint with the top cover 27 is formed. Inside the side cover 23 in the neighborhood thereof, infrared distance sensors 10a to 10c are arranged. The infrared distance sensors 10a to 10c measure the distances up to articles positioned opposite the sensors 10a to 10c. Output signals from the sensors 10a to 10c are monitored by the controller 6. The parts of the side cover 23 opposite to the light receptors of the infrared distance sensors 10a to 10c are made of a material capable of transmitting infrared light. Therefore, the distance between the self-propelled cleaning device 1 and a neighboring article can be recognized by the controller 6.

In the cleaning device 1, a gyro-sensor (not shown in the drawing) is mounted. The gyro-sensor outputs a signal representing the angular speed of the self-propelled cleaning device around a shaft in the vertical direction and sends this signal to the controller 6. By doing this, even if the drive wheels 4a and 4b slip on the floor, the angular speed of the self-propelled cleaning device 1 can be detected.

On the lower part of the cleaning device 1 on both sides toward the front, level difference sensors 12a and 12b are mounted so as to face downward. The level difference sensors 12a and 12b are reflection type infrared distance measuring sensors, and they output a signal which indicates the existence of an article within the range at a predetermined distance from the light receptors of the sensors 12a and 12b. By doing this, if the floor in the forward direction of the self-propelled cleaning device 1 is hollow, the sensors can detect it. When the level difference sensor 12a or 12b detects a level difference when the cleaning device 1 is moving, it stops the cleaning device 1 once. And, in such case, the cleaning device 1 changes its

direction to a direction that is free of a level difference. By doing this, the cleaning device 1 is prevented from falling down steps, for example. For the level difference sensors 12, in addition to the infrared sensors, ultrasonic sensors or contact switches can be used.

The dust collection structure in the cleaning device 1 will be explained in detail below. In the neighborhood of the suction body 30 that is movable in the transverse direction, a dust collection case 21 is installed. As shown in Figs. 2(a) and 2(b), in the face of the suction body 30, which is in contact with the dust collection case 21, a hole 70 is bored. Also, in the face of the dust collection case 21 which is in contact with the suction body 30, a hole 71 is bored. Through the holes 70 and 71 that are provided in the suction body 30 and the dust collection case 21, air including dust which is sucked in by the suction body 30 passes. Around the hole 71 formed in the dust collection case 21, a packing 36 is mounted. The packing 36 is used to maintain air-tight contact between the suction body 30 and the dust collection case 21. The surface of the part of the packing 36 in contact with the suction body 30 is processed smoothly.

On a base 45, a dust collection fan 20 is mounted. On the bottom side of the base 45, the dust collection case 21 is positioned. The dust collection fan 20 is connected to the dust collection case 21 via the base. In the connection part of the base 45 between the dust collection case 21 and the dust collection fan 20, an intake air ventilation hole is bored. When the dust collection case 21 is mounted on the cleaning device 1, a packing (not shown in the drawing) keeps the flow path air-tight.

On the part of the dust collection case 21 opposite to the dust

collection fan 20, a non-woven filter 54 is mounted. Due to the pressure difference caused by the operation of the dust collection fan 20, air including dust is sucked in from the suction body 30. Air including dust moves to the dust collection fan 20 from the suction body 30 through the dust collection case 21. And, dust and air are separated by the dust collection filter 54, and the separated dust is collected in the dust collection case 21.

The holes 70 and 71 are respectively bored in the suction body 30 and the dust collection case 21 to form an air flow path, so that the suction body 30 can move transversely by sliding on the packing 36 on the dust collection case 21 (refer to Figs. 2(a) and 2(b)). Therefore, no hose and pipe are required, and the cleaning device 1 can be miniaturized. Compared with the case in which the dust collection case 21 and the suction body 30 are moved together with each other, the moving part can be lightened and the force required to move the suction body 30 can be made smaller. As a result, the drive device for moving the suction body 30 in the transverse direction can be miniaturized. The movable range of the suction body 30, as shown in Fig. 2(b), is such that the hole 70 of the suction body 30 is not projected from the area surrounded by the packing 36 when the suction body 30 is most projected and is such that the left end of the suction body 30 does not move beyond the left end of the packing 36.

The dust collection case 21 is controlled in its transverse movement by a guide (not shown in the drawing) which is attached to the base 45. However, the dust collection case 21 can slide forward along the guide. In this way, the dust collection case 21 can be removed from the cleaning device

1. When the packing 36 installed at the back end of the dust collection case 21 presses the dust collection case 21 into the self-propelled cleaning device 1 up to the position where it makes contact with the suction body 30, a pawl 28 installed on the dust collection case is fit into a hollow 29 formed on the side of the cleaning device 1. In this way, the movement of the dust collection case 21 in the forward direction can be controlled. The pawl 28 is elastic and when dust collection case 21 is strongly pulled forward, the pawl 28 is deflected down. And, the engagement between the pawl 28 and the hollow 29 on the side of the cleaning device 1 is released and the dust collection case 21 can be easily removed from the cleaning device 1.

The upper cover of the dust collection case 21 can be removed from the dust collection case 21. Therefore, when the dust collection case 21 is removed, dust collected in the dust collection case 21 can be easily discarded. Further, the dust collection case is removable, and the slideways between the dust collection case 21 and the suction body 30 are exposed, so that the slideways can be easily cleaned.

To move the suction body 30 in the transverse direction, there is a drive system including a suction body feed motor 32, an encoder 34 mounted to the motor 32, a ball screw 37 connected to the shaft of the motor 32, a suction body origin detection switch 90, and a support arm 42 for suspending and supporting the suction body 30 from above. The suction body 30 is connected to the ball screw 37 via the support arm 43. The ball screw 37 is supported rotatably by bearings 35 held by support members 45a which are almost rigidly attached to the base 45. The connection part for connecting

the support arm 42 to the ball screw 37 is a pin 43 and a female screw is cut on the inner surface thereof. When the ball screw 37 rotates, the suction body 30, the pin 43, and the support arm 42 move in the transverse direction.

The encoder 34 detects the extent of movement of the pin 43 and outputs this information to the controller 6. The suction body origin detection switch 90, when the pin 43 is within a predetermined range, is arranged so as to be switched on. And, when the pin 43 is beyond the predetermined range, it is switched off. The ON and OFF switching position is used to set the origin of the suction body 30. When the origin detected by the suction body origin detection switch 90 and the output value of the encoder 34 are combined, the absolute value of the position of the support arm 42 is known. In this embodiment, the positional origin is determined by a mechanical method. However, needless to say, an optical sensor may be used.

On the support arm 42, a slider 33 that is movable in the transverse direction is mounted. To return the slider 33 to the neutral position, the slider 33 has a spring 33b. When a transverse force is applied to the suction body 30, the slider 33 moves according to the magnitude of the force. When the motor 32 is rotated, the suction body 30 moves in the transverse direction by sliding along the dust collection case 21.

According to this embodiment, the tip of the suction body 30 is supported by the support arm 42 via the slider 33, so that the tip of the suction body 30 can reach the neighborhood of a wall. Further, when the projected tip of the suction body 30 makes contact with an external article such as a wall, the self-propelled cleaning device 1 can be prevented from changing direction in response to a reaction force from the article. When the

spring force of the slider 33 is made sufficiently weak, even if the projected tip of the suction body 30 makes contact with an article, the suction body 30 and contacted article can be prevented from being damaged.

In the neighborhood of the part of the suction body 30 that projects from the self-propelled cleaning device 1, a contact detection sensor 44 is attached. The contact detection sensor 44 is composed of a plurality of switches arranged in a sheet shape, so that, when the cleaning device 1 makes contact with a wall or an obstacle, a corresponding switch is actuated. The contact detection sensor 44 outputs the contact position to the controller 6. By doing this, the contact detection sensor 44 can detect when the projected part of the suction body 30 makes contact with a wall or an article.

The operation of the self-propelled cleaning device 1 having such a constitution will be explained below. The self-propelled cleaning device 1 has two modes of movement, including an automatic movement mode and a manual movement mode. In the automatic movement mode, the self-propelled cleaning device 1 executes automatic movement on the basis of information received from various sensors mounted on the self-propelled cleaning device 1. In the manual movement mode, the self-propelled cleaning device 1 performs a single operation, such as forward movement, backward movement, or rotation on the basis of a signal transmitted from the remote control transmitter 100.

At the start of operation of the self-propelled cleaning device 1, the manual movement mode is set. In the manual movement mode, a user selects the direction of movement of the cleaning device 1 using the remote control transmitter 100. Therefore, the user is able to move the cleaning

device 1 to a room to be cleaned without setting the manual movement mode and lifting up and carrying the cleaning device 1, thus the physical burden imposed on the user can be lessened. During the operation in the manual mode, when the cleaning device 1 is instructed by a signal received from the remote control transmitter 100 or the switch on the operation panel 46 of the cleaning device 1, the self-propelled cleaning device 1 is shifted to the automatic movement mode. In the automatic movement mode, on the basis of an algorithm stored in the controller 6 beforehand, the cleaning device 1 moves so as to clean throughout the whole room using the output of various sensors, such as the infrared distance measuring sensors 10a to 10c.

By use of the self-propelled cleaning device 1 of this embodiment, during automatic movement, the area in the vicinity of a wall or an obstacle can be cleaned. Therefore, when cleaning near a wall, the self-propelled cleaning device 1 moves along the wall. During movement along the wall, a predetermined spacing is maintained between the self-propelled cleaning device 1 and the wall surface. The predetermined spacing, when the suction body 30 is projected to the full extent, is smaller than the distance at which the suction body 30 makes contact with the wall.

The difference between the distance to the wall which is measured by the infrared distance measuring sensor 10a and the target distance is obtained. When the difference between the two distances is positive, the self-propelled cleaning device 1 is instructed to approach the wall. When the difference between the two distances is negative, the self-propelled cleaning device 1 is instructed to move away from the wall. Until the contact detection sensor 44 detects that the tip of the projected part of the suction body is in

contact with the wall, the suction body 30 is projected. Or, on the basis of the distance from the self-propelled cleaning device 1 to the wall, which is detected by the infrared distance measuring sensor 10a, the amount of projection of the suction body 30 is determined. By the latter method, when the amount of projection of the suction body 30 is adjusted, the area in the neighborhood of the wall can be cleaned free of contact by the tip of the suction body 30 with the wall.

According to this embodiment, even if an article is caught by the front of the projected suction body 30 during movement, the contact detection sensor 44 can detect the object, so that the suction body is retracted at once in the self-propelled cleaning device 1, thus the cleaning can be continued while avoiding the obstacle.

When cleaning in the neighborhood of the wall, the self-propelled cleaning device 1 often must rotate in the corners of the room. Fig. 4 shows an example of the rotation of the self-propelled cleaning device 1. When the self-propelled cleaning device 1 reaches one corner of the room during moving along the wall in the automatic movement mode, the infrared distance measuring sensors 10a and 10b detect the wall. Then, the self-propelled cleaning device 1 is shifted to the operation of rotation in place for purposes of cleaning the corner. At this time, when the amount of projection of the suction body 30 is controlled so as to move the tip of the suction body 30 along the wall, the amount of non-cleaned area in the corner can be reduced.

The amount of projection of the suction body 30, similar to the general movement along the wall, is determined on the basis of information obtained from the contact detection sensor 44 or information concerning the distance

from the self-propelled cleaning device 1 to the wall, which is detected by the infrared distance measuring sensor 10a. The infrared distance measuring sensor 10a precedes the tip of the suction body 30 in the rotational direction (counterclockwise in Fig. 4) of the self-propelled cleaning device 1, so that the sensor can confirm the shape of the corner before the tip of the suction body 30 passes the corner. In this way, in correspondence to the shape of the corner, the movement of the suction body 30 can be controlled so as not to make contact with the wall and to get as close to the wall as possible. Even if the wall is made of a material that is easily damaged, no damage is caused to the wall. Further, when determining the amount of projection of the tip of the suction body 30, a program based on the assumption that the corners of the room are right-angled may be used. In this case, the cleaning device 1 can be controlled simply.

The side cover 23 has a notch formed in the part from which the suction body 30 is projected. By provision of this notch, the suction body 30 can move smoothly. On the lower part of the front of the side cover 23, to remove the dust collection case 21, a hatch 26, which is opened by sliding it vertically, is provided.

On the base 45 in the neighborhood of the inner peripheral surface of the side cover 23, four springs 25a to 25d are mounted almost at even intervals. The springs 25a to 25d are made of a piano wire, as seen in Fig. 5 and they are hardly stretchable in the longitudinal direction, but easily move in the bending direction. Thus, when the load is removed, the springs are returned. The springs 25a to 25d are arranged vertically as shown in the partial cross sectional view in Fig. 5 in detail.

At the upper end of the top cover 27, a step 27a bent inward is formed. The step 27a prevents the side cover 23 from moving downward. By the step 27a, even if downward force is applied to the side cover 23, the top cover 27 supports the force to prevent the springs 25a to 25d from buckling. Further, by provision of the step 27a of the top cover 27, the amount of movement of the side cover 23 in the horizontal direction is restricted to about 3 mm. Furthermore, the springs 25a to 25d are hardly deformed by tensile strength, so that even if the side cover 23 of the self-propelled cleaning device 1 is lifted up, the side cover 23 will not be separated from the base 45.

Switches 24a to 24d for detecting relative horizontal movement of the side cover 23 are arranged at a slight interval from the side cover 23. The switches 24a to 24d are held by the tips of brackets 72a to 72d that are installed perpendicularly to the base 45. When the side cover 23 moves in any direction horizontally into contact with an article, one or two switches 24a to 24d make contact with the side cover 23 and the switches 24a to 24d operate. Depending on which switch is operated among the switches 24a to 24d, the rough direction of the article can be determined. The output of the switches 24a to 24d is supplied to the controller 6. Therefore, when any side of the cleaning device 1 makes contact with an article and the side cover 23 moves, the contact with the article can be detected.

According to this embodiment, the whole periphery of the side cover 23 is integrally formed and is softly supported by the springs, and the four contact switches are installed at a pitch of almost 90 degrees, so that even if the cleaning device 1 makes contact with an article at any position, there is no dead angle of detection. Further, the detection mechanism requires few

parts and the structure is simple and inexpensive. The parts required for detection can be arranged in the neighborhood of the side cover 23 of the cleaning device 1, so that space for other parts can be reserved in the central part of the self-propelled cleaning device 1. The side cover 23 is supported by the top cover 27, so that the structure is strong against external force in the vertical direction. The rough direction of an article in the path of the cleaning device can be known, so that an avoidance operation can be performed easily.

Further, by simply changing the rigidity of the springs 25a to 25d, the detection sensitivity can be easily changed. When the horizontal clearance between the top cover 27 and the side cover 23 is changed, the horizontal movable range of the side cover 23 can be changed. When the rigidity of the springs 25a to 25d and the horizontal movable range are properly combined, soft-touch contact detection is made possible. In this setting, the self-propelled cleaning device 1 and a peripheral article can be prevented from making contact with each other and causing damage to each other.

In this embodiment, to support the side cover, the four springs 25a and 25d are used, and to detect the movement of the side cover, the four switches 24a to 24d are used. However, the number of these elements is not limited to 4. The number of the springs 25 and the number of the switches 24 may be different from each other. The switches are not limited to a rounded shape used in the aforementioned embodiment and may be a polyhedron having rounded angles. In any case, no dead angle is generated in detection.

To the suction body 30, a pressure sensor (not shown in the Drawing)

is attached. The pressure detected by the pressure sensor is outputted to the controller 6. When the self-propelled cleaning device 1 is in use, a situation may be caused in which the suction port 40 is blocked by paper, for example, and dust cannot be sucked in. At this time, the pressure in the suction body 30 is suddenly lowered. When this state is continued for many hours, the motor 20a for driving the dust collection fan 20 enters an overload state and the self-propelled cleaning device 1 fails. Thus, the pressure sensor detects pressure changes in the suction body 30, and the overload state of the motor 20a is avoided.

More specifically, when the pressure sensor 13 detects a sudden pressure reduction, it stops the suction of the cleaning device 1 at once. When the suction is stopped, the pressure in the suction body 30 becomes equal to the atmospheric pressure and the article attached to the suction port 40 can be removed easily. Thus, the cleaning device 1 moves by a predetermined distance, and then the article attached to the suction port 40 is removed. The suction is restarted, and it is confirmed that the pressure is returned to its normal pressure, and then the cleaning is restarted. When the pressure difference is not returned to the normal state, the aforementioned suction stop and movement of the cleaning device 1 are repeated. When the pressure is not returned to the normal pressure even if the above procedure is repeated by a predetermined number of times, the suction is stopped and the cleaning is stopped. To inform the user of an error, the indicator 17 indicates the error.

As dust is collected in the dust collection case 21, the pressure reduction in the suction body 30 in the suction state gets smaller. The

pressure sensor monitors the pressure when the dust collection fan 20 is in operation, so that the collection state of dust in the dust collection case 21 can be detected. The dust collection state is indicated to the user by the indicator 17. Since the dust collection state can be detected, the dust removal timing from the dust collection case 21 can be indicated automatically.

The cleaning device 1 uses the storage battery 22 as a power source, so that a charging operation is required. Further, the capacity of the dust collection case 21 is limited, so that when a predetermined amount of dust is collected, it is necessary to remove the dust from the dust collection case 21. In this embodiment, these operations are automatically performed by the cleaning device 1. This situation will be explained with reference to Figs. 6 to 8.

Figs. 6(a) and 6(b) show the self-propelled cleaning device 1 and a charger 200 installed in a corner of a room, in which Fig. 6(a) is a top view thereof, and Fig. 6(b) is a side view thereof. The charger 200 has a lower plate 201, a side wall 202, a box 203, and a charger guide 204. Figs. 7(a) to 7(c) show the charger guide in detail, in which Fig. 7(a) is a top view thereof, Fig. 7(b) a side view, and Fig. 7(c) is a cross sectional view taken along the line A-A in Fig. 7(a).

The box 203 is a power supply unit installed on the building side. The guide 204 is connected to the box 203 and is used, when charging the cleaning device 1, to smoothly connect to the power contacts of the cleaning device 1. On the end face of the box 203 on the side of the guide 204, charging terminals 205 are installed. The charging terminals 205 are

electrically connected to a charging circuit 230 installed in the box 203. To the charging circuit 230, commercial power is supplied.

In the box 203, there are a charger dust collection fan 206, a charger dust collection case 207, and a charger controller 250. The charger dust collection case 207 has a larger dust collection capacity than that of the dust collection case 21 of the self-propelled cleaning device 1. The charger controller 250 monitors and controls the current and voltage supplied from the charging circuit 230 to the charging terminals 205 and controls the operation of the charger dust collection fan 206.

On the charger guide 204, a guide 208, which is shaped to get narrower in width toward its tip, and a trapezoidal dust suction port 209 surrounded by guide 208 are formed. At the edge of the top of the guide 208, a flange 208a is formed. The top of the dust suction port 209 is higher than the top of the guide 208. The dust suction port 209 is interconnected to the charger dust collection case 207 via a suction path 210 formed inside the guide.

When the charger dust collection fan 206 is operated, air is sucked in from the dust suction port 209. And, dust included in the sucked air is separated by a filter 207a held in the charger dust collection case 207 and this dust is collected in the charger dust collection case 207. In this way, dust collected in the dust collection case 21 of the cleaning device 1 is moved to the dust collection case 207 on the side of the charger 200.

Figs. 8(a) and 8(b) show the dust collection case 21 of the self-propelled cleaning device 1 in detail to which the guide 204 of the charger 200 shown in Fig. 7(a) is joined. Fig. 8(a) shows a state in which a shutter

59 installed on the bottom of the dust collection case 21 is closed, and Fig. 8(b) shows a state in which it is opened.

On the bottom of the dust collection case 21, a dust ejection port 60 is formed, and the dust ejection port 60 is covered by the shutter 59. The shutter 59 slides in the forward direction of the self-propelled cleaning device 1. On the back of the dust collection case 21, springs 61 are mounted, and the springs 61 press the shutter 59 to the left as seen in the darwing. During the normal operation of the cleaning device 1, the dust ejection port 60 is covered by the shutter 59, so that and dust in the dust collection case 21 can not escape (refer to Fig. 8(a)).

When the shutter 59 is pressed to the right, the springs 61 are shrunk and the dust ejection port 60 appears as shown in Fig. 8(b). At the front edge of the shutter 59, a bending part 62 bending downward is formed. When joining the self-propelled cleaning device 1 to the charger 200, the lower end of the bending part 62 is set so as to be higher than the top of the charger guide 208 and lower than the edge of the dust suction port 209. On both sides of a dust ejection port 58, a guide 63 is installed. The guide 63 is in a relationship of male and female with the guide 208 of the charger 200. When joining the self-propelled cleaning device 1 to the charger 200, the heights of the guides 63 and 208 are set so that the height of the guide 63 coincides with the height of the guide 208. Further, when joining the guide 208 to the guide 63, the charging terminals 14 and 205 are set so that the charging terminal 205 makes contact with the charging terminal 14 of the cleaning device 1.

The dust ejection operation of the self-propelled cleaning device 1

having such a constitution will be explained below with reference to Figs. 6(a) to 8(b). The side wall 202 of the charger 200 is installed beforehand in contact with the wall of a room. If the voltage of the storage battery 22 is lowered below a predetermined value when the self-propelled cleaning device 1 is in operation, the controller 6 judges that the residual charge of the battery is too low. In such case, the controller 6 moves to the charging operation. When the controller 6 moves to the charging operation, the self-propelled cleaning device 1 goes straight on and searches for the wall of the room. When the controller 6 judges that the cleaning device 1 reaches the wall from the output of the switches 24a to 24d of the side cover or of the contact detection sensor 44 of the suction body 30, the cleaning device 1 moves along the wall so that the wall is positioned on the right of the cleaning device 1. When the cleaning device 1 continues its movement along the wall and reaches the charger 200, it rides on the lower plate 201 along the side wall 202 of the charger 200.

During the movement along the side wall 202, the cleaning device 1 moves forward away from the wall by a distance determined on the basis of the distance from the guide 208 to the side wall 202. By doing this, when the self-propelled cleaning device 1 rides on the lower plate 201 of the charger 200, the guide 208 on the side of the charger 200 and the guide 63 on the side of the self-propelled cleaning device 1 are located almost just opposite to each other.

When the self-propelled cleaning device 1 continues its movement along the side wall 202, the front wheels of the guide 63 on the side of the self-propelled cleaning device 1 automatically fit into the tip of the guide 208

on the side of the charger 200. And, finally, the two guides 208 and 63 engage each other. At that time, the charging terminals 14 on the side of the self-propelled cleaning device 1 and the charging terminals 205 on the side of the charger 200 make contact with each other, and the power supply is started, whereby the storage battery 22 is charged.

As the self-propelled cleaning device 1 continues its movement along the side wall 202, the shutter 59 of the self-propelled cleaning device 1 is caught by the edge of the dust suction port 209 of the charger 200. Next, the shutter 59 is pressed and opened by the guide 204, and the dust suction port 209 and the dust ejection port 58 are positioned just opposite to each other. When the controller 6 of the self-propelled cleaning device 1 detects that the contact terminals 14 and the charging terminals 205 on the side of the charger 200 are under current supply, it stops the movement of the cleaning device 1.

The charger controller 250 detects the current flowing in the charging terminals 205 and judges that the self-propelled cleaning device 1 is joined to the charger 200. The controller 250 then operates the charger dust collection fan 206 for a predetermined time and sucks in dust from the dust collection case 21 of the self-propelled cleaning device 1 into the charger dust collection case 207. The suction is continued for a predetermined time.

When the charger controller 250 or the controller 6 of the self-propelled cleaning device 1 determines that the dust suction is completed and then judges that charging of the storage battery 22 has been completed, the self-propelled cleaning device is moved backward. Thus, the charging terminals 208 on the side of the charger 200 and the charging terminals 14 on the self-

propelled cleaning device side are separated from each other. Or, using the controller 6 of the self-propelled cleaning device 1 or the charger controller 250, the supply of voltage to the storage battery 22 is stopped. Since both charging and dust ejection are completed, the cleaning is restarted when necessary.

According to this embodiment, dust in the dust collection case 21, which is conventionally discarded by hand, is moved automatically to the dust collection case 207 on the side of the charger 200, so that the capacity of the dust collection case 21 on the side of the cleaning device 1, which typically requires a large capacity for automatic cleaning, can be reduced. By doing this, the cleaning device can be miniaturized. Further, in the aforementioned embodiment, dust is separated using a filter. However, the centrifugal method used in an electric cleaning device may be used as well.

Further, according to this embodiment, without the need for a large capacity storage battery and dust collection case, the cleaning can be carried out in a wide area or for many hours. Since a physical guide is used, an automatic charging and dust ejection system having a simple structure and high reliability can be realized.

Another embodiment of the present invention is shown in Fig. 9(a) and 9(b). In the aforementioned embodiment, the dust collection case is arranged on the lower part of the cleaning device. In this embodiment, the dust collection case is arranged on the upper part of the cleaning device. Therefore, the dust collecting system installed on the charger side is different from that provided in the aforementioned embodiment. Figs. 9(a) and 9(b) show the cleaning device 1a stored in a charger 200a, in which Fig. 9(a) is a

top view thereof, and Fig. 9(b) is a side cross sectional view thereof.

A dust collection case 21 of the cleaning device 1a is held by a dust collection case holder 73 that is installed on a top cover 27b. On the top of the dust collection case 21, a check valve 77 is installed; and, around the check valve 77, there is a tapered mouthpiece 76, which is depressed as viewed from the outside. The mouthpiece 76 is made of a ferromagnetic material, such as iron. The top of the dust collection case 21a is made of a transparent resin, except for the mouthpiece 76 and the check valve 77.

The suction body 30, like the aforementioned embodiment, can move in the transverse direction. The suction body 30 and the dust collection case 21 are connected by a duct 78, which extends vertically. At the upper end of the duct 78, a sliding plate 74 is mounted. The sliding plate 74 can slide on a packing 75 that is attached to the dust collection case holder 73. The guide 63, which is attached to the bottom of the dust collection case 21 in the aforementioned embodiment, is attached to the bottom of the cleaning device 1a in this embodiment. However, the shutter 59 and the dust ejection port 60 arranged around the guide 63 are not required in this embodiment.

Also, in this embodiment, the constitution of the charger 200a is the same as that in the aforementioned embodiment, though only the side plate 202a and the box 203a are different from those of the aforementioned embodiment. The box 203a is positioned above the side plate 202a, and it is positioned so as to cover only almost the front half of the cleaning device 1a when the cleaning device 1a is connected to the charger 200a. A flexible hose 220 extends from the charger dust collection fan 206, and the hose 220 sucks in dust.

At the tip of the hose 220, an electromagnet 221 is mounted, and the current to the electromagnetic 221 is controlled by the charger controller 250 (not shown in these figures). The tip of the hose 220 is pulled to the outside of the box 203a; and, when the cleaning device 1a is positioned at the charging position, the mouthpiece 76 is positioned right under the tip of the hose 220. A guide 204 of the charger 200a is the same as the guide used in the aforementioned embodiment.

The operation of this embodiment will be explained below. Until the cleaning device 1a is connected to the charger 200a, the state is the same as that of the aforementioned embodiment. When the charger 200a is connected to the cleaning device 1a, the movement of the cleaning device 1a is stopped. The charger 200a detects that the charging terminals 14 on the side of the cleaning device 1a and the charging terminals 205 on the charger side are in contact with each other, and charging is started.

The flexible hose 220 is extended and the tip of the hose 220 is brought into contact with the mouthpiece 76. The charger controller 250 applies power to the electromagnet 221 at the tip of the hose 220. The electromagnetic 221 is magnetized and an attractive force is applied between the magnet and the ferromagnetic mouthpiece 76. At this time, the electromagnet 221 and the mouthpiece 76 surely cling close to each other due to the presence of a tapered fitting structure and are held in close contact by the magnetic attraction.

The charger dust collection fan 206 is operated and the check valve 77 is opened by the generated pressure. Dust in the dust collection case 21 is sucked into the charger dust collection case 207. When the charger dust

collection fan 206 is operated for a predetermined time, the power supply to the electromagnet 221 is stopped. By the elasticity of the hose 220, the tip of the hose 220 is separated from the mouthpiece 76. Then, the transfer of dust from the dust collection case 21 to the charger dust collection case 207 is finished. The subsequent operation is the same as that of the aforementioned embodiment.

According to this embodiment, the side walls 202 and 202a are installed on respective sides of the charger 200a, so that the cleaning device 1 is prevented from entering into the charger 200a from the side of the charger 200a. The dust collection case 21 is installed on the top of the main unit and is made of a transparent resin, so that the amount of dust in the dust collection case 21 can be confirmed visually. Further, a situation can be prevented in which an article of value is sucked in and is discarded together with the dust by mistake. The box 203a is structured so as to be high, so that the occupied floor area of the charger 200a can be reduced. The box 203a covers only the front portion of the cleaning device 1a, so that the operation panel 46 and the infrared remote control receiver 16, which are arranged behind the cleaning device 1a will be exposed. As a result, even if the cleaning device 1a is stored in the charger 200a, it can be easily operated or remote-controlled.

A modification of this embodiment is shown in Fig. 10. Fig. 10 is a side cross sectional view of the cleaning device 1a and a charger 200c. Also in this embodiment, like the aforementioned embodiment, the box 203c is positioned above the side plate 202c, though it is different in that the box 203c is positioned above the whole length of the charger 200c.

On the top of the charger 200c, there are an operation panel 222 and an infrared remote control receiver 223, similar to the operation panel 27a and infrared remote control receiver 16 installed in the cleaning device 1a. The outputs of the operation panel 222 and the infrared remote control receiver 223 are input to the controller 250 installed in the box 203c. On the bottom of the box 203c, an infrared remote control transmitter 224 is installed. The transmitter 224 receives an instruction from the controller 250 and transmits a remote control signal to the remote control receiver 16 of the cleaning device 1 stored in the charger 200c. On the upper part of the inner surface of the part where the self-propelled cleaning device 1 is stored, an entry detection sensor 229 is provided for detecting the entry of the self-propelled cleaning device 1 into the charger 200c, and the output of the sensor 229 is input to the controller 250.

When the switch on the operation panel 222 is pressed or when the infrared remote control receiver 223 receives a signal from an infrared remote control transmitter (not shown in the drawing), the infrared remote control transmitter 224 transmits a corresponding signal to the remote control receiver 16 of the cleaning device 1a. In this way, even if the cleaning device 1a is stored in the charger 200c, the cleaning device 1a can be operated. Further, the whole upper part of the charger 200c is constituted by the box 203c, so that the charger 200c can be made more compact.

When the entry detection sensor 229 detects that the self-propelled cleaning device 1a has entered into the charger 200c, the controller 250 transmits a signal to instructs the cleaning device 1a via the infrared remote control transmitter 224 indicating the entry of the cleaning device 1a into the

charger 200c. By doing this, even if the cleaning device 1a enters the charger 200c unexpectedly during its movement, the cleaning device 1a can change its direction of movement before it engages with the charger 200c.

Further, when the cleaning devices 1a does not enter into the charger 200c, the entry detection sensor 229 is not operated, so that it can be determined that the cleaning device 1a is not in the charger 200c and the moving speed thereof can be increased. As a result, when joining the cleaning device 1a to the charger 200c, the cleaning device 1a moves to the neighborhood of the charger 200c at high speed, and the speed of movement is decreased in the neighborhood of the charger 200c, thus the cleaning device 1a can reach the charger 200c quickly. As a result, before the cleaning device 1a reaches the charger 200c, the speed of movement can be increased; and, after it reaches the charger 200c, the speed of movement can be decreased, so that the efficiency of the cleaning can be improved and the charging and dust ejection operation can be performed surely.

Further, if the position of the infrared remote control transmitter 224 and the shape of the side plate 202 are selected so as to prevent a signal transmitted from the infrared remote control transmitter 224 from leaking outside the charger 200c, the entry detection sensor 229 may be omitted. In this case, a signal indicating entry always may be transmitted from the infrared remote control transmitter 224.

According to the present invention, the suction body is movable, so that movement of the side cover can be used detect the direction of an obstacle, whereby every corner of a room can be automatically cleaned. Further, the guide and dust ejection means are installed in the charger, so

that the charging and dust ejection can be executed without manual operation, and automatic cleaning by the self-propelled cleaning device can be realized. Simultaneously, cleaning for many hours or in a wide area can be realized. Furthermore, the self-propelled cleaning device can be miniaturized.